ROCKETDYNE

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TO R. J. Lodge DEPARTMENT 596-160

FROM E. S. Hutmacher DEPARTMENT 596-162

PHONE 5554 DATE 1 February 1961

SUBJECT Evaluation of VTS-1 Cryogenic Run Vessel for Liquid Hydrogen Service

Ref.: 1. AVO, E. T. Higgins to P. A. Yount, dated 26 September 1960, Subject: "Use of VTS LOX Run Tank for Liquid Hydrogen."

2. I.O.L., E. S. Hutmacher to E. Higgins, dated 19 September 1960. Same subject.

CONCLUSIONS:

1. The cryogenic vessel has been designed, fabricated and tested in accordance with ASME requirements for service at -320°F.

2. The vessel is constructed of 347 or the equivalent type 321.

3. The cryogenic data books list properties of 347 or 321 stainless steel in the annealed condition at -425°F which shows an increase of tensile strength of 130 percent, an increase in yield of approximately 30 percent with no loss in ductility.

4. A cryogenic vessel constructed for service at -320°F is fabricated of the same material and the same welding methods as one for service at -423°F. The only difference is that impact values are taken on the test samples at -423°F. *

5. Sufficient test evidence exists to substantiate the notch toughness of the weld material, which is the primary criterion generally considered for materials at low temperatures, at the -423°F temperature.

6. The vessel meets all requirements of the ASME code except the impact tests at -423°F. *

RECOMMENDATIONS:

1. Since the vessel cannot be operated as a code vessel at -423°F it should be restricted to a maximum of 300 psi while personnel are in the area. This is 15 percent of the design value at -320°F or a safety factor of slightly more than 26. This had been approved by the Safety Dept. (Ref. 1).

* MOST 347 VESSELS THAT ARE NOT HEAT TREATED WOULD NOT PASS CHARPY TESTS, AT -320°F

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2. As an added precaution the operating pressure of the vessel should always be maintained as low as possible, while operating at the -423°F level.

3. Some action should be taken with the state and ASME code personnel to obtain deviations to operate vessels at the lower temperatures where laboratory tests of weld specimens indicate the impact values are substantially above the 15 ft-lb charpy keyhole or 18 ft-lb Izod V notch at -320°F.

DISCUSSION:

The VTS-1 run vessel was originally designed and fabricated for service at -320°F. The vessel was no longer required for the program originally intended and could be easily modified for hydrogen service. It was planned to code the vessel for -423°F service, however, test samples of the shell were no longer available and it was not considered advisable to damage the shell to obtain samples for test.

The modifications were minor and the ASME code on the vessel could be maintained for service at -320°F. The specifications were prepared under these conditions and the vessel now carries that code.

There is no reason to conclude that a vessel designed for -320°F service is not suitable also for -423°F service. The vessel meets all requirements of the ASME code except that impact tests were not conducted at the temperature of service. This, however, poses no real problem since the preponderance of test data on materials at subzero temperatures shows little change of the suitable materials from -320°F to -425°F.

Some concern may be expressed that the metal may undergo phase transformation (austenitic to martensitic structure) at -423°F. Tests with commercial 347 stainless steel at -452°F in notch tension did not reveal embrittlement even though 25 percent of the material in the region of the notch had transformed (Ref. 1). Tests show that good impact strength is retained after prolonged usage (Ref. 4).

Typical tensile and yield tests of welded 347 stainless steel (Ref. 4) are as follows:

Temp °F	Yield, Psi	Tensile, Psi
75	35,000	90,000
-320	41,200	186,000
-425	45,500	210,000

Charpy keyhole impact valves of 347 stainless plate and welded material are as follows (Ref. 3, 4).

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Test Temp °F	Plate	Welded Plate	
	Ft/lb	Ft/lb	
	Annealed	As welded	Annealed
75	68	27	25
-320	63	19	18
-425(extrapolated)	62	17	16.5

With the above data it is safe to conclude that if the vessel was fabricated properly for -320°F service it is also suitable for the -423°F. The recommended precautions should be taken for personnel safety in accordance with present methods of operation.

TECHNICAL REFERENCES:

1. Bailey, B.M., et al, "Handbook for Hydrogen Handling Equipment," WADC Technical Report 59-751, February 1960.

2. "Cryogenic Materials Data Handbook", National Bureau of Standards, FP No 161093 through 161093-6.

3. Chelton, D. B., D. B. Mann, "Cryogenic Data Book" WADC Technical Report 59-8, Department of Commerce, Printing Dept, 1956.

4. McConnell, J. H., R. R. Brady, "Austenitic Stainless Steels", Chemical Engineering, July 11, 1960.

5. "Stainless Steel Handbook," Alleghany Ludlum Steel Corp., 1956.

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